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The Use of Educational Technologies to Equip Students with 21st Century Skills

Therese Keane, *tkeane@swin.edu.au*
Swinburne University, John Street Hawthorn, Victoria 3122, Australia

William F. Keane, *william.keane@emmaus.vic.edu.au*
Emmaus College, 503 Springvale Rd Vermont South, Victoria 3133, Australia

Aaron S. Blicblau, *ablicblau@swin.edu.au*
Swinburne University, John Street Hawthorn, Victoria 3122, Australia

Abstract
From the end of the last century, information and communication technologies (ICT) have begun a process of transformation of both education and industry. Now and into the future students need the skills to operate in the 21st century. This requires the development of personalised learning that is broader than the 3Rs of reading, writing and arithmetic in order to establish that students are equipped to take their place in the 21st century. What is needed in addition to the 3Rs are the 4Cs of critical thinking & problem solving, effective communication, collaboration & team building and creativity & innovation. The use of ICT is fundamental for the kind of personalised learning needed for the development of the 4Cs but, as the SAMR model makes clear, simply using ICT does not guarantee that the necessary deep learning will occur. What is crucial is the transformative use of ICT for learning. The present work provides direction to teachers who wish to lead in a technological environment of change.

Keywords
learning, 21st century skills, 4Cs, 3Rs

INTRODUCTION
From the end of the last century, there has been a saturation of information and communication technologies (ICT) in both education and industry. While students have demonstrated their enthusiastic use of ICT including the use of the Internet, mobile devices, smart phones and social media (Jacob & Issac, 2008), teachers have been challenged in the use of these technologies for pedagogical applications in the classroom. Students need to be prepared for the 21st century in which they require a skillset that is broader than the 3Rs of reading, writing and arithmetic, which have long been considered to be foundations of learning.

Teachers need to be able to operate in a Generation Z world, also referred to as the Technology Generation by Tucker and Bari (2010), who define this generation as “technically savvy, well adapted at communicating via the Internet, and used to instant action due to the Internet technology they have always known” (pp. 37-38). Teachers need to be able to use and appreciate the technology their students use on a daily basis and understand how it can be applied to a curriculum that embraces the technological knowledge and interest of todays’ ICT savvy student. The ability for teachers to be able to use educational technologies in their field of expertise pro-

vides opportunities for students to work towards technological competencies incorporated in their work environment. This approach may fill the missing gap between student expectations of their classroom and the teacher's delivery of the curriculum material. However, without an understanding of learning, the use of transformative (Keane & Blicblau, 2012) technology may be ineffectual. The present work provides direction to teachers who wish to lead in a technological environment of change.

UNDERSTANDING LEARNING

For some time assertions have been made about the power of ICT to transform learning (Papert, 1993). One significant aspect of the transformative power of ICT is its ability to shift control of learning to the learner (November, 2010). It is reasonable to ask why this shift of control is important for teaching and this question needs to be understood in terms of how we learn (Bransford, 2000).

Early conceptions of learning implied that learning was passive so that "learning was something that happened to the learner" (Stoll, Fink, & Earl, 2003, p. 23). This understanding of learning led to an emphasis on filling the empty vessel (the learner) with content. This view of learning is compatible with the belief – widely held in the first half of the 20th Century – that intellectual capacity could be measured by a test and that it was something you either had or you did not have (Roid & Barram, 2004).

As interest developed in understanding how individual learning took place, this view began to be challenged. Piaget's (1953) influential work identified four distinct developmental stages from birth to adulthood with each stage being a specific step in developmental progress. While Piaget's theories were based on observations of individual learning, Vygotsky (1962) was interested in understanding how learning was shaped by the social context and this led to his work on the zone of proximal development which can be understood as the gap between what learners can do by themselves and what they can do with others. Piaget and Vygotsky can be seen as the forerunners of constructivism, which provides a way to understand learning. Constructivism can be understood as the process whereby learners construct knowledge by developing ways that allow them to add new information to existing knowledge in order to build understanding. While constructivism is a theory of learning, it is sometimes described as if it were a theory of teaching (Loughran, 2010).

Furthermore, the central role of the learner in determining what is learnt is elaborated by metacognition, a term first described by Flavell (1976). He defined metacognition as "the individual's awareness, consideration and control of his or her cognitive processes and strategies" (p. 231). Metacognition is therefore the ability to monitor and control thinking process. This can be seen in terms of the kinds of questions we ask ourselves about a task such as: what do I do next? How well did I do? The introduction of this sense of executive control has been very important in terms of understanding our ideas about thinking and learning.

Ideas about intelligence have also undergone modification over time. Gardner's (1983) theory of multiple intelligences described eight intelligences which rarely operate independently of one another. Gardner's work explained how different individuals are predisposed to learning in different kinds of ways: spatial, linguistic, kinaesthetic, musical, interpersonal, intrapersonal, naturalistic and existential. Because of this mix of learning styles, learners learn in ways that are essentially unique to them and this should be taken into account when constructing learning activities. In a similar vein Costa and Kallick (2000) identified 16 Habits of Mind which lead to successful learning. These Habits are best described as psychological dispositions, which the learner brings to the task.

Just as ideas about learners have been subject to change, distinctions can be made between different kinds of learning. In developing the Taxonomy of Educational Objectives, Bloom (1956) outlined a way of categorising instructional objectives and assessment according to increasing levels of cognitive complexity. His

classification was based on the idea that different learning objectives are the result of different skills and abilities and that some objectives are easier or harder than others. Bloom's Taxonomy defined thinking skills into six categories (using nouns), each of which was built up from the previous one: knowledge, comprehension, application, analysis, synthesis, and evaluation. Bloom's Taxonomy is, essentially, a hierarchical structure. Partly to take into account using technology as a mode of instruction, Bloom's Taxonomy was later revised to reflect the changes in the educational landscape (Anderson et al., 2001). The revised taxonomy replaced the nouns with verbs to form the following categories: remembering, understanding, applying, analysing, evaluating and creating.

Bloom's work had a major impact on education as it introduced the concept of higher-order thinking skills which leads, in turn, to distinctions between surface learning (trying to remember facts in unconnected ways) and deep learning (integrating new information with prior learning).

Understanding the difference between surface learning and deep learning is important. In researching what Marton and Saljo (1976) described as "meaningful learning in the true sense of the term" (p. 11), they examined students' approaches to reading texts. What they found was that there was significant qualitative differences between what students learned and this was determined by whether they adopted a largely rote learning strategy to remember the text itself (surface learning) or whether they were more focussed on using strategies which focussed more on the author's meaning (deep learning).

The distinction between surface and deep learning is a key feature of the SOLO Taxonomy (Biggs & Collis, 1982). SOLO, which stands for the Structure of the Observed Learning Outcome, is a means of classifying learning outcomes in terms of their complexity, enabling students' work to be assessed in terms of its quality. The SOLO Taxonomy describes how, once students move beyond unfamiliarity with the material (pre-structural), surface learning responses require one idea (uni-structural) or many ideas (multi-structural). Deep learning responses require students to relate ideas (relational) or extend ideas (extended abstract). Surface learning is typically quantitative in nature where students recall facts or lists to put together. In contrast, deep learning is essentially qualitative where students are required to form judgements and think conceptually.

An understanding that decisions made by the learner determine the quality of learning (White & Baird, 1991) along with a focus on deep learning for understanding has led to the development of the concept of personalised learning (Keamy, Nicholas, Mahar, & Herrick, 2007). The key features of personalised learning are:

- Learners are central
- Information and communications technology (ICT) is a key enabler
- Lifelong learning
- Communities of collaboration.

Personalised learning requires the connective power of ICT to develop ways of thinking and learning which empower the learner. While many traditional elements of education remain important "We need to move our thinking beyond our primary focus and fixation on the Three Rs (3Rs) – beyond traditional literacy to an additional set of 21st century fluencies, skills that reflect the times we live in" (Crockett, Jukes, & Churches, 2012, p. 17).

CRYSTALLISING 21ST CENTURY SKILLS

In a changing technological context, schools need to focus on more than just the basics 3Rs – which can be described as surface learning – and develop a personalised learning approach in the context of 21st century skills – deep learning – in order to prepare students for the future. Silva (2008) argues that, "integrating 21st century skills into teaching and assessment, then, is not only an economic imperative, driven by changes in the workforce, but a vital aspect of improving learning" (p 12). The link

between education and employment is highlighted in both the US and the European Union. For example, the report "The New Commission on the Skills of the American Workforce" (2006) concluded that it is basic skills, along with creativity and innovation, which are essential for future economic and job security. A "21st Century Skills Discussion Paper" prepared by the Universiteit of Twente on behalf of Kennisnet, acknowledged that:

> Information and Communication Technology (ICT) is at the core of 21st century skills. Specifically, it is regarded as both (**a**) an argument for the need of 21st century skills, and (b) a tool that can support the acquisition and assessment of these skills. In addition, the rapid development of ICT requires a whole new set of competences related to ICT and technological literacy (Voogt & Roblin, 2010, p. i).

A later joint EU-US Study, on "Emerging Skills and Competences" identified ICT as paramount in the development of innovative approaches to 21st century education and lifelong learning (Shapiro, Lauritzen, & Irving, 2011).

The need to forge a new learning approach has resulted in the development of a number of major skills definitions of which we focus on three. The combined Commonwealth and State Government body MCEETYA (Ministerial Council for Education, Employment, Training and Youth Affairs), the American Management Association (2010) and AT21CS (2012), (a world wide collaboration amongst ICT industry and educational institutions) have all attempted to identify the essential and necessary skills for teachers and students into the 21st century.

MCEETYA Necessary Skills Definition

The requirement to ensure that students obtain the necessary 21st century skills has been recognized in the Australian Curriculum (Australian Curriculum Assessment Reporting Authority, 2012), which is guided by the Melbourne Declaration (MCEETYA, 2008). The main findings of the Declaration were that successful learners for the 21st century needed:

- To have the essential skills in literacy and numeracy and be creative and productive users of technology, especially ICT, as a foundation for success in all learning areas
- To be able to think deeply and logically, and obtain and evaluate evidence in a disciplined way as the result of studying fundamental disciplines
- To be creative, innovative and resourceful, and be able to solve problems in ways that draw upon a range of learning areas and disciplines
- To be able to plan activities independently, collaborate, work in teams and communicate ideas

AMA Critical Skills Definition

The American Management Association (AMA) commissioned a Critical Skills Survey (2010) which identified the skills that employers wanted their employees to have beyond the 3Rs. In fact, the survey emphasised that employers wanted their employees to have further developed skills in the 4Cs for workforce readiness in the 21st century. The 4Cs identified were:

- Critical thinking & problem solving
- Effective communication
- Collaboration & team building
- Creativity & innovation

Critical thinking is vital for problem solving. Often situations that are complex, uncertain and have no precedent require employees to solve problems. Critical thinking is the discipline of actively and skilfully conceptualizing, applying, analysing, synthesizing and/or evaluating information gathered from, or generated by observation, experience, reflection, reasoning or communication.

Whilst students take for granted that they can communicate with others, there are various degrees of communicating effectively. To explain complex ideas, a concise, organized and measured approach is necessary. And to solve problems, students need to interact in teams. This provides the necessary social and learning environment to solve problems. Often educators underestimate the importance of working globally in virtual teams and asynchronously. As we are now heavily reliant on technology, and can use tools to assist in communicating with teams that may be dispersed internationally, collaboration and team building are necessary skills.

Creativity may be defined as pushing the boundaries to develop new ideas, and innovation is the development of these ideas into actuality. For example, though mobile phones were around for at least 20 years, the late Steve Jobs was able to convince the public in June 2007 that his new creation of the iPhone© (Isaacson, 2011) with its multi-media, touch screen, combined a number of innovative technologies such as a music player, camera, wireless internet connection, Bluetooth and Apps, was the mobile phone to have!

AT21CS Essential Skills Definition

The development of skills incorporating the 4Cs, is complemented by the protocols of AT21CS (2012) which described the essential skills necessary for a knowledge based economy as being based on learning to collaborate with others and connecting with technology. These essential skills were categorised as:

- Ways of thinking-creativity, critical thinking, problem-solving, decision-making and learning
- Ways of working-communication and collaboration
- Tools for working-information and communications technology (ICT) and information literacy
- Skills for living in the world-citizenship, life and career, and personal and social responsibility

There is common ground amongst the three approaches – MCEETYA, AMA and AT21CS – in both working and teaching and learning perspectives. The essential skills that are common to the three approaches can be mapped, as shown in Figure 1. A synthesis of these three approaches involves thinking, collaboration, communication and creativity as the necessary skills for working in the 21st century.

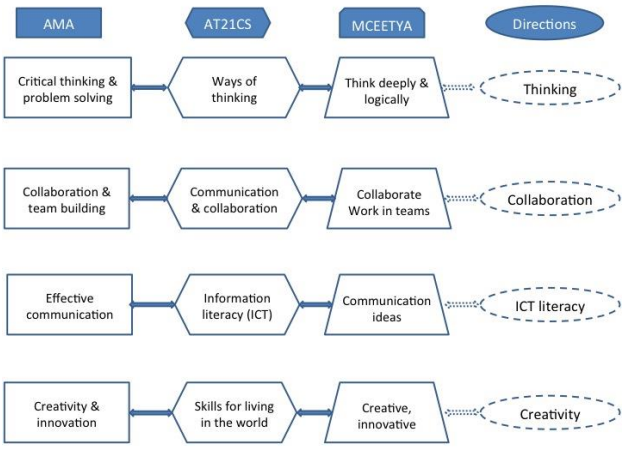

Figure 1: Common ground amongst the three approaches, MCEETYA, AMA and AT21CS

21st Century Skills ≅3Rs + 4Cs

Technology is central to the development of the 4Cs. There are those groups like Partnership For 21st Century Skills – a national American organization – that promotes the importance of 21st century readiness for every US student by fusing the

3Rs and the 4Cs and providing resources and tools for these skills (Partnership for 21st Century Skills, 2012). Students in the 21st century live in a technology and media rich environment where they have access to a plethora of information, new, powerful digital tools, and the ability to collaborate and communicate with others.

TOWARDS A FRAMEWORK FOR PERSONALIZED LEARNING WITH TECHNOLOGY ADOPTION

To be effective learners, students need to be able to integrate the 4Cs in an online world. It is tempting, then, to believe that the simple way to address the development of the 4Cs is by providing students with computer devices. Certainly there has been a good deal of government policy that has been based on the assumption that access to technology is the key to achieving success. However, simply providing students with mobile devices such as netbooks, iPads©, tablets, and laptops will not develop these skills and enhance their learning. What the teacher does in the classroom with these devices is important for developing a personalized student learning scheme for technology adoption.

The SAMR Model developed and enhanced by Puentedura (2011) divides technology usage into four distinct level as depicted in Figure 2. In this model, *substitution* is the lowest level of technology usage where it is used to simply replace whatever was being done without that technology. For example, a word processor – without the use of enhanced features for editing – is used as a substitute for pen and paper. At the next level, *augmentatio*n is where the technology acts as a direct tool with some functional improvement, following on from the previous example, the use of sophisticated editing functions are used is this level. For example, the difference between *substitution* and *augmentation* is the use of features to improve the product. However, only basic learning skills take place. These two levels of technology use are defined as the *enhancemen*t stage.

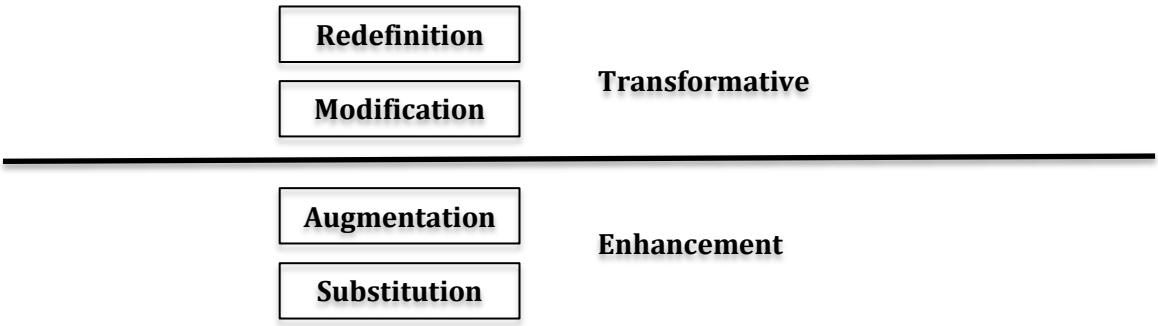

Figure 2: SAMR Model for Technology Adoption

Whereas, in the *enhancement* stage, the task could have been completed satisfactorily without using technology, at the *modification* level the task becomes something quite different. So that rather than complete a word-processed piece to be printed out, the writing becomes part of a blog, wiki or social network exchange. The final level of *redefinition* is where the technology allows for the creation of new tasks previously inconceivable. This final level is difficult to describe as we are constantly redefining what is possible using technology in advance forms. These two levels, *modification* and r*edefinition* are identified as the *transformative* stage. It is proposed that teachers use the higher levels of the SAMR model in relation to technology adoption as their framework to improve student outcomes. The SAMR framework provides a dialogue to frame a discussion around teaching achievements and future directions.

What the SAMR model shows us is, when technology is only used in the *enhancement* stage, there is only a minimal effect on learning (Herrington, Herrington,

Mantei, Olney, & Ferry, 2009). As mastery of the 4Cs requires deep learning, ICT use needs to be *transformative* to provide the ideal conditions for powerful learning. According to Oostveen, Muirhead & Goodman (2011), "It seems that meaningful learning is far more likely if the new technologies are recognized as providing transformative opportunities" (p. 83).

CONCLUDING COMMENTS

What happens in the classroom with technology usage in schools too often occurs at the *enhancement* rather then *transformative* stage and is therefore more aligned with surface rather than deep learning. Therefore we need to provide the appropriate situations that will allow students to develop a mastery of the 4Cs. Hattie (2009) argues "It is what teachers get the students to do in the class that emerged as the strongest component of the accomplished teachers' repertoire, rather than what the teacher, specifically, does. Students must be actively involved in their learning, with a focus on multiple paths to problem solving" (p. 35).

Now and into the future students need the skills to operate in the 21st century. This requires a transformation in educational philosophy to focus on personalised education. The use of technology needs to align and adapt with what we know about learning in order to function in a transformative space. Therefore, using ICT in the *transformative* stage is crucial to enable students to be flexible in their critical thinking and problem solving methodology, be effective communicators, work collaboratively in teams and develop their creativity. The 3Rs alone are not sufficient to provide students with the appropriate skills required to function in the 21st century. Instead, there needs to be a fusion of the 3Rs with the 4Cs. Future work needs to focus on developing the 4Cs for teacher professional development and evaluating student outcomes in a technological transformative environment.

REFERENCES

American Management Association. (2010) Retrieved 13 April, 2012, from http://www.amanet.org/organizations/2010-survey-critical-skills.aspx

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Wittrock, M. C. (2001). *A Taxonomy for learning, teaching, and assessing : a revision of Bloom's taxonomy of educational objectives*. New York: Longman.

AT21CS. (2012). What are 21st-century skills? Retrieved 8 November, 2012, from http://atc21s.org/index.php/about/what-are-21st-century-skills/

Australian Curriculum Assessment Reporting Authority. (2012). ACARA Retrieved 3 June 2012, from http://www.acara.edu.au/

Biggs, J. B., & Collis, K. F. (1982). *Evaulating the quality of learning: The SOLO taxonomy (structure of the observed learning outcome)* New York: Academic Press.

Bloom, B. S., Engelart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives : The classification of educational Goals; handbook I: Cognitive domain*. New York: Longmans, Green.

Bransford, J. (2000). *How people learn brain, mind, experience, and school*. Washington, D.C.: National Academy Press.

Costa, A. L., & Kallick, B. (2000). *Discovering & exploring habits of mind*. Alexandria, VA: ASCD.

Crockett, L., Jukes, I., & Churches, A. (2012). *Literacy is not enough: 21st century fluencies for the digital age*. Australia: Hawker Brownlow Education.

Flavell, J. (1976). Metacognitive aspects of problem solving. In L. Resnick (Ed.), *The Nature of Intelligence* (pp. 231-235). New Jersey: Erlbaum.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Hattie, J. A. C. (2009). *Visible learning. A synthesis of over 800 meta-analysies relating to achievement*. New York: Routledge.

Herrington, J., Herrington, A., Mantei, J., Olney, I., & Ferry, B. (2009). New technologies, new pedagogies: Mobile learning in higher education (pp. 1-138). Retrieved from http://ro.uow.edu.au/newtech/

Isaacson, W. (2011). *Steve Jobs*. New York: Simon & Shuster.

Jacob, S. M., & Issac, B. (2008, 19-21 March). *The mobile devices and its mobile learning usage analysis.* Paper presented at the International MultiConference of Engineers and Computer Scientists, Hong Kong.

Keamy, K., Nicholas, H., Mahar, S., & Herrick, C. (2007). Personalising education: from research to policy and practice. Victoria: Department of Education and Early Childhood Development.

Keane, T., & Blicblau, A. S. (2012, 25-28 November). *(Trans) formation through educational technologies.* Paper presented at the 29th Annual Australasian Society for Computers in Learning in Tertiary Education (ASCILITE 2012), Wellington, New Zealand.

Loughran, J. (2010). *What expert teachers do*. Australia: Allen & Unwin.

Marton, F., & Saljo, R. (1976). On qualitative differences in learning I, Outcome and process. *British Journal of Educational Psychology, 46*, 4-11.

MCEETYA. (2008). Melbourne Declaration on Educational Goals for Young Australians. Canberra: Curriculum Corporation.

November, A. (2010). Power down, power up? In H. H. Jacobs (Ed.), *Curriculum 21: Essential Education for Changing World* (pp. 186-194). Alexandria, VA: ASCD.

Oostveen, R. V., Muirhead, W., & Goodman, W. M. (2011). Tablet pcs and reconceptualizing leaning with technology: a case study in higher education". *Interactive Technology and Smart Education, 8*(2), 78-93.

Papert, S. (1993). *Mindstorms: Children, computers and powerful ideas.* (2nd ed.). New York: Basic Books.

Partnership for 21st Century Skills. (2012) Retrieved 13 April, 2012, from http://www.p21.org/index.php

Piaget, J. (1953). *Logic and psychology*. Manchester: Manchester University Press.

Puentedura, R. (2011). Metaphors, models, and Flows: Elements for a cartography of technology in learning Retrieved 13 April, 2012, from http://www.hippasus.com/rrpweblog/archives/000061.html

Roid, G. H., & Barram, R. (2004). *Essentials of Stanford-Binet intelligence scales (SB5) Assessment*. Hoboken: John Wiley & Sons, Inc.

Shapiro, H., Lauritzen, J. R. K., & Irving, P. (2011). Emerging Skills and Comptences - A Transatlantic Study: European Commission, DG Education.

Silva, E. (2008). Measuring skills for the 21st century. 1-18. Retrieved from http://www.educationsector.org/publications/measuring-skills-21st-century

Stoll, L., Fink, D., & Earl, L. (2003). *It's about learning [and its about time] What's in it for schools?* London: RoutledgeFalmer.

The New Commission on the Skills of the American Workforce. (2006). Tough choices or tough times. Washington DC: National Center on Education and the Economy.

Tucker, J., & Bari, C. (2010). *Utilizing the internet to facilitate classroom learning*. Journal of College Teaching & Learning*, 7*(7), 37-44.

Voogt, J., & Roblin, N. P. (2010). 21st Century Skills Discussion Paper. Netherlands: Universiteit Twente.

Vygotsky, L. (1962). *Thought and language*. Cambridge, MA: MIT Press, published originally in Russian in 1934.

White, R., & Baird, J. (1991). Learning to think and thinking to learn. In J. B. Biggs (Ed.), *Teaching for learning. The view from cognitive psychology* (pp. 146-176). Victoria, Australia: The Australian Council for Educational Research.

Biographies

Dr. Therese Keane is an Educational Technology lecturer in the Faculty of Information and Communication Technologies. Therese has worked in a variety of school settings overseeing the teaching and stewardship of ICT in schools. Therese's research interests include the use of technology and computers in schools for teaching and learning purposes; Mobile computing devices in schools (notebooks, netbooks, iPads, tablets, smartphones) and ICT leadership in schools.

Dr. William F. Keane has been at Emmaus College (Melbourne, Australia) as the Assistant Principal in charge of Teaching and Learning. Prior to coming to Emmaus William held a number of positions in Catholic schools. He has extensive experience in innovation and development in curriculum, assessment and reporting and the implementation of 1:1 computing programs.

Mr. Aaron S. Blicblau has held appointments as a project engineer for a large mining and manufacturing company before commencing his academic appointment at Swinburne University of Technology. His current work is involved with investigating and implementing strategies for the teaching of technologically literate students to prepare them for working in 21st century.